NUREG-0769
Addendum No. 1

Final Environmental Statement

related to the operation of Enrico Fermi Atomic Power Plant, Unit No. 2

Docket No. 50-341

Detroit Edison Company

U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

March 1982

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SUMMARY AND CONCLUSIONS

Subsequent to the issuance in August 1981 of the Fermi 2 Final Environmental Statement (FES) related to the operation of Enrico Fermi Atomic Power Plant, Unit No. 2 (NUREG-0769), the staff discovered it had not included a response to comments on the Fermi 2 Draft Environmental Statement received from the U.S. Department of the Interior. The Department of the Interior comments related to the possible impact on population exposure from atmospheric fallout of radionuclides on the Great Lakes, including Lake Erie, and groundwater transport of radionuclides to Lake Erie following a postulated accident at Fermi 2. Numerical computations of exposure hazards through these pathways were not included in the staff's FES.

In response to these Department of Interior comments, the staff has computed the radiation exposure that may be received by an individual or the population by use of the waters and shorelines of the Great Lakes following hypothetical accidents, including fallout on the lakes and releases to groundwater. This Addendum to the FES presents the results of these computations and the staff's response to other comments made by the Department of the Interior. The staff has concluded that, with mitigation, doses to both an individual and the population through the Great Lakes pathways would be less than those reported for land pathways in the FES.

The Summary and Conclusions in the FES issued in August 1981 are not changed as a result of considerations in this Addendum, and are, therefore, still applicable.

NRC staff contributors to this Addendum include S. Acharya, H. Berkson, R. Codell, C. R. Hickey, Jr., G. Hulman, W. Meinke, W. Pasedag, R. Samworth, and D. West. John White and K. F. Eckerman of ORNL also were principal contributors.

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6.1.6 Effects of Atmospheric Fallout on the Great Lakes

The Department of the Interior's comments on the Draft Environmental Statement for the Enrico Fermi Atomic Power Plant Unit No. 2, dated June 18, 1981, raised questions relating to possible impacts from atmospheric fallout and groundwater transport of radionuclides from potential accidents at the Fermi 2 reactor. In Section 6.1.1.2, "Exposure Pathways," in "Final Environmental Statement Related to the Operation of Enrico Fermi Atomic Power Plant, Unit No. 2" (August 1981, NUREG-0769), the staff recognized that fallout on open bodies of water of radioactivity released to the atmosphere from reactor accidents could lead to radiation exposure to humans. Numerical estimates of such exposure hazards were not provided by the staff in the analysis of severe accidents at the Fermi 2 reactor in FES Section 6.1.4.2. Moreover, dose estimates involving accidental releases to groundwater were not evaluated explicitly, but were compared to those made in other cases.

For land-based nuclear power plants at sites which are inland and far from large surface water bodies, radiation exposures via aquatic pathways that could originate from atmospheric fallout of radioactivity from severe accidents on nearby small water bodies--such as streams, rivers, ponds, and small lakes--are generally expected to be much smaller than the exposures from pathways originating from fallout on land surfaces. This expectation is based primarily on the fact that the ratio of the area of surface water bodies to the area of the land surfaces at many inland sites over which radionuclide fallout would take place is very small; thus, over a period of time only a small fraction of the fallout on the land would be washed or leached into surface waters and could be expected to contribute materially to doses. For nuclear power plants at coastal sites, on the other hand, radiation exposures from aquatic pathways as a result of fallout on the seawater (salt water) would also be small compared to exposures from other pathways mainly because of the large dilution that would be provided by the sea. In addition, expected doses would be smaller because drinking water would not be a pathway of exposure and population concentrations over the water would be less. The Fermi 2 site, on the western end of Lake Erie, is different from both coastal and inland sites.

On the basis of the atmospheric dispersion model used in the Reactor Safety Study (RSS) (NUREG-75/014)* and in the analysis presented in FES Section 6.1.4.2, all of the Great Lakes are potentially within reach of the radioactive plume that would be formed following an atmospheric release of radionuclides in a severe accident in the Fermi 2 reactor. Because most of the Great Lakes have relatively large surface areas, appreciable fractions of radionuclides from the plume could be deposited on one or more of these lakes by atmospheric fallout. However, for any of the Great Lakes to be contaminated by the atmospheric fallout of radioactivity after an accident, the wind would have to be blowing toward the lake.

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*References cited in this Addendum section are listed at the end of this Chapter, in Section 6.2.1.

The staff's probabilistic evaluation of the radiation exposure that may be received by an individual or the population by use of the waters and the shorelines of the Great Lakes that might be contaminated by fallout from accidents at the Fermi 2 reactor is presented below. To evaluate the accident consequences, the staff used two computer codes: CRAC, developed for the RSS, and the Liquid Pathway Generic Study (LPGS) (NUREG-0440) code. The former was used to calculate radionuclide deposition on the Great Lakes by atmospheric fallout for releases from the Fermi 2 reactor. The latter was used to assess the radiological consequences of fallout on the lakes and releases to groundwater.

6.1.6.1 Atmospheric Fallout of Radionuclides on the Great Lakes

6.1.6.1.1 Magnitude of Radioactivity in the Atmospheric Release

In the probabilistic assessment of accidents in the Fermi 2 FES, the staff used the accident sequences, their probabilities of occurrence per reactor-year, and fractions of the core inventory of radionuclides associated with the atmospheric release as presented in FES Table 6.3. For the detailed analysis presented in this Addendum, only the first of the sequences in FES Table 6.3, designated TC_γ', was selected for analysis. Because of all sequences in FES Table 6.3, the sequence $TC\gamma'$ is associated with the largest values of the release fractions, the magnitudes of the consequences of the atmospheric fallout on the Great Lakes from this sequence would provide estimates of the upper limit of the consequences from the other sequences in FES Table 6.3. This sequence is beyond the design basis events evaluated in the staff's Safety Evaluation Report for Fermi Unit 2 (NUREG-0798). It is referred to as a Class 9 accident sequence and is the most severe of the boiling water reactor (BWR) accident sequences considered. However, to compensate for the exclusion of the other sequences from detailed calculations, the staff has used the sum of the probabilities of all sequences in FES Table 6.3 (2.43×10^{-5} per reactor-year) for weighting the calculated consequences from the TC_γ' sequence in the estimates of overall risks. Because the calculated consequences for the $TC\gamma'$ sequence are the upper limit values for other sequences, the estimates of risks made using such a weighting would also represent the upper limit values of risks from all sequences in FES Table 6.3. That is, risks calculated by combining all the sequences in FES Table 6.3 would be less than the values presented in this Addendum.

The quantities of radionuclides that would be released to the atmosphere from the selected accident sequence in the Fermi 2 reactor were calculated by multiplying the core inventory of the radionuclides given in FES Table 6.1 by the release fractions for this sequence given in FES Table 6.3. These quantities are shown in Table 6.6 in this Addendum.

6.1.6.1.2 Radionuclide Deposition on the Great Lakes

The CRAC computer code was used to calculate radionuclide concentrations in the atmosphere and radionuclide deposition on the ground from atmospheric fallout in the analysis of severe accidents presented in the FES. In this analysis, for the calculation of radionuclide deposition on the Great Lakes surfaces, this code was modified by simply assuming that the lake surfaces replace the ground surfaces. To obtain average magnitudes of radionuclides on the lake surfaces as functions of distance, calculations were performed assuming the occurrence of releases of radionuclides in Table 6.6 at each of 91 different start times (sampling times) distributed uniformly throughout a 1-year period. This is the same stratified sampling scheme used in the FES analysis. Both analyses used meteorological data from the Fermi 2 site representing a full year of consecutive hourly measurements.

Approximate but conservative estimates of radial and angular (or sector) spans of the Great Lakes with respect to the Fermi 2 site are presented in Table 6.7. These were also used to estimate radionuclide deposition on the lake surface. It was assumed that the quantity of radioactivity that would enter a lake, given that the wind is blowing toward it, was the amount that would be deposited within the entire radial span of the lake, without regard to the cross-wind widths of the plume during its propagation. The annual average probability that the wind would be blowing toward each lake was assumed to be the sum of the annual average probabilities of the wind blowing toward the sectors included in the angular span of each lake. Table 6.8 shows estimated annual average probabilities of wind blowing toward each of the Great Lakes and the estimated average magnitudes (sampled over 91 start times) of radionuclides that would fall on the Great Lakes, given the occurrence of the atmospheric release of radionuclides in Table 6.6.

Runoff of radionuclides deposited on the land surfaces into the lake was not included because doses thus resulting would be expected to occur much later and then at very much lower concentration levels than would be expected from direct fallout on the lakes themselves (Simpson, Ng). This conclusion is derived from comparisons of radioactivity levels in surface waters following the atmospheric tests of nuclear weapons to levels existing prior to about 1960.

6.1.6.2 Dose to an Individual and to the Population as a Result of the Atmospheric Fallout of Radionuclides on the Great Lakes

6.1.6.2.1 The Lake Model

The calculational model selected by the staff for assessment of the dose to an individual and the population from use of the waters and shorelines of the Great Lakes is the Completely Mixed Lake Model with Bottom Sedimentation that was developed by the staff in connection with the LPGS described in Section B-2.3 of NUREG-0440. This model is considered to simulate an actual release situation in an acceptable manner. The calculational models of NUREG-0440 are computer-implemented in the LPGS code, which also was developed by the staff. This code is currently undergoing minor revision and documentation at the Technical Data Management Center of Oak Ridge National Laboratory.

In applying the Completely Mixed Lake Model with Bottom Sedimentation into the analysis for Fermi 2, it was assumed that the radionuclides deposited on the surface of a Great Lake mix completely in the entire volume of water in the lake within a relatively short time. This simplified assumption is considered generally adequate for computational purposes because most dose accumulations would occur over relatively long periods of time, after complete mixing would be expected. After this initial mixing, loss of radioactivity from lake water was assumed to take place as a result of the following:

(1) radioactive decay

(2) flushing out of the lake at the average annual rate of flow $q(m^3/yr)$ through the lake

(3) direct exchange of radionuclides from the water to the sediment layer by a process similar to molecular diffusion at a constant rate K_f(cm/yr)

(4) deposition of sediment and "attached" radionuclides onto the lake bottom with a constant deposition velocity v(cm/yr)

A fraction of the adsorbed radionuclides on material deposited in the bottom layer would be available to leach back into the water. This "gain back" of radionuclides to the water was also taken into account. For modeling of leaching, an effective constant thickness d_2(cm) of the bottom sediment was assumed. Values of these and other parameters characterizing the Great Lakes used as inputs to the LPGS code for the present analysis are shown in Table 6.9.

Each of the Great Lakes was treated as an independent lake, that is, not connected to the other Great Lakes. Although the lakes are actually in series, the staff verified that the removal by sedimentation of the largest radionuclide contributors to doses in the water of each lake was so great that the amount transported to the next lake in the series would cause a negligible error. Therefore, the single-lake model was found adequate.

Although the 48 radionuclide species shown in Table 6.8 could be deposited on the surfaces of the Great Lakes, only 40 of the most important radionuclide species were used in the LPGS code for each lake for dose calculations. The eight radionuclide species that were excluded were Y-90, Zr-97, Tc-99m, Ru-105, Tc-127, Tc-129, Sb-129, and I-134. These species were found to be small contributors to the calculated dose by assessing Lake Erie doses with and without these radionuclides in a preliminary analysis.

Solutions of the Completely Mixed Lake Model with Bottom Sedimentation equations provide values of radionuclide concentrations in the lake water as functions of time. These time-dependent radionuclide concentrations were incorporated into the dose models described in Appendix C of NUREG-0440.

6.1.6.2.2 Individual and Population Dose Consequences

Doses to an individual and to the population that would result from contamination of the Great Lakes were calculated for the four following aquatic pathways of exposure to humans:

(1) recreational activities on the shorelines contaminated by transfer of radioactivity from lake waters to the lake shores

(2) swimming in the contaminated lakes

(3) consumption of drinking water drawn from the contaminated lakes

(4) consumption of fish caught from the contaminated lakes

Dosimetric models used for individual and population dose calculations are described in Appendix C of NUREG-0440. One modification was made to the equation for time-dependent concentrations of radionulides on the shoreline to account more realistically for the loss of radionuclides as a result of environmental causes. It was assumed that the effective environmental half-life of all radionuclides on the shoreline would be 50 years, which is quite conservative compared to approximately 35 years for the effective half-life for ground contamination assumed in the RSS. No such loss of shoreline contamination as a result of environmental causes was assumed in NUREG-0440.

Doses to an individual were calculated assuming equal values of radionuclide concentrations at all locations on the shoreline of the lake. These calculational assumptions are generally conservative with respect to population dose estimates.

Conservative values of population usage parameters for the four pathways for each of the Great Lakes as used in the calculations are shown in Table 6.10.

Accumulations of doses to an individual (rems) or the population (person-rems) would be functions of the times over which the contaminated pathways are used. The concentration levels of radionuclides in the pathways would, however, decrease with time. Calculations of cumulative doses were made for periods ranging from a day to 100 years following an accident for each of the Great Lakes. The results, which assume no interdiction, are presented in Tables 6.11 and 6.12.

6.1.6.3 Health Consequences and Risks to an Individual and the Population Resulting from Atmospheric Fallout of Radionuclides on the Great Lakes

6.1.6.3.1 Health Consequences to an Individual and the Population from Fallout on the Great Lakes

Tables 6.11a through 6.11e show that the highest whole-body dose that would be received by an individual would result from unrestricted use of Lake Erie. The total dose to the individual was estimated to level off at about 60 rems after about 3 years of normal use of the lakes. Because 60 rems to the whole body is below the threshold dose for lethality, early death of any individual would not be expected. Also, early injury to any individual would not be expected because of the low rate at which the dose would be delivered.

Tables 6.12a through 6.12e show estimated population exposures from unrestricted use of Lakes Erie, Huron (including Lake St. Claire and Georgian Bay), Michigan, Ontario, and Superior, respectively, of 9×10^{7}, 2×10^{6}, 2×10^{6}, 5×10^{5}, and 2×10^{5} person-rems. On the basis of the estimate of 140 cases of random occurrence of delayed cancer fatalities per million person-rems over the lifetimes of the exposed population, the preceeding values of population exposures could result in about 10,000, 300, 300, 70, and 30 total delayed cancer deaths, respectively. The total number of genetic effects would total about twice the preceeding numbers in succeeding generations. It should be noted that the preceeding values of delayed cancer fatalities have their respective probabilities, including the probability of the fallout on the

Great Lakes. These probabilities are derived as the products of the assigned probability of 2.43×10^{-5} per reactor-year for the atmospheric releases and the probabilities of the wind blowing toward one of the Great Lakes. The calculated values of these probabilities are 6×10^{-6}, 7.5×10^{-6}, 4.5×10^{-6}, and 3×10^{-6} per reactor-year, respectively, for Lakes Erie, Huron (including Lake St. Claire and Georgian Bay), Michigan, Ontario, and Superior, and are indicated in Tables 6.11 and 6.12.

6.1.6.3.2 Risks to an Individual and Society

The estimated whole-body dose of 60 rems to an individual from unrestricted use of the Lake Erie after contamination (probability 6×10^{-6} reactor-year) was used to estimate the risk of delayed cancer fatality to this individual of about 5×10^{-8}* per reactor-year. The estimated risk to the total population who normally use the Great Lakes for drinking water, aquatic foods, and recreational activities was estimated to be about 6×10^{-2}** per reactor-year of operation of the Fermi 2 facility. On this basis the staff concludes that the societal risk via the liquid pathway is small.

6.1.6.4 Comparison of Consequences and Risks from Fallout on Great Lakes with Estimates Made in the FES

Societal health consequences at various probability levels and the resulting risks from exposure pathways from the air and the ground contaminated by atmospheric releases from the Fermi 2 reactor in all the accident sequences presented in FES Table 6.3 were shown in FES Tables 6.4 and 6.5. The estimated values of societal consequences of delayed cancer fatalities with their respective probabilities, and the overall societal risk of delayed cancer fatality per reactor-year presented in Section 6.1.6.3, represent best estimate upper limit (see Section 6.1.6.1.1) values for all the sequences in FES Table 6.3 resulting from accidental contamination by direct atmospheric fallout on the Great Lakes. Furthermore, these estimates assumed no mitigation measures. These values were found to be of the same order of magnitude as the values shown in FES Tables 6.4 and 6.5 The best estimate upper limit value of 5×10^{-8} per reactor-year of the risk of delayed cancer fatality to an individual calculated in Section 6.1.6.3 is of the same order of magnitude as values indicated in FES Figure 6.9.

Estimates of consequences and risks from fallout on the Great Lakes from all the accident sequences in FES Table 6.3 would be lower than the best estimate upper limit values provided in this analysis. Notwithstanding this conservatism, the staff concludes that addition of the estimated risks from severe accidents in Fermi 2 as a result of atmospheric fallout of radioactivity on the Great Lakes to those already presented in the FES does not alter the

*This was calculated as follows: 60 rems x $1.4 \times 10^{-4} \frac{\text{cancer death}}{\text{rems}} \times 6 \times 10^{-6}$ probability per reactor-year = 5×10^{-8} per reactor-year.

**This was calculated as follows: $6 \times 10^{-6} \times 10{,}000$ (from Lake Erie) + $7.5 \times 10^{-6} \times 300$ (from Lake Huron, including Lake St. Claire and Georgian Bay) + $4 \times 10^{-6} \times 300$ (from Lake Michigan) + $4.5 \times 10^{-6} \times 70$ (from Lake Ontario) + $3 \times 10^{-6} \times 30$ (from Lake Superior) = 6×10^{-2} per reactor-year.

comparison made in the FES of the comparability of risks from severe accidents and from routine operation of this facility, or the risks from other hazards (see FES Section 6.1.4.6).

Furthermore, the population dose consequences indicated in Tables 6.12a through 6.12e, and the potential doses to a maximally exposed individual indicated in Tables 6.11a through 6.11e, assume unrestricted use of the Great Lakes following very severe accidents. The population exposures indicated in the FES for atmospheric releases, however, indicate population exposures in which credit for interdiction and decontamination have been accumulated. For example, if attempts are made to limit population exposures from Lake Erie, or any of the other Great Lakes, solely by interdicting the fish pathway for a period of about 1 year following a severe accident, more than 50 percent of the population dose and the associated potential for latent cancer fatalities and genetic effects could be eliminated. Furthermore, if interdiction of only the edible fish pathway is undertaken for an extended period of time, most of the potential doses to a maximally exposed individual and the population in general can be avoided.

6.1.6.5 Uncertainties in the Estimates

The estimates of the consequences and risks made in the analysis described above have large uncertainties. The subject of uncertainties in this type of probabilistic calculation is briefly and qualitatively addressed in FES Section 6.1.4.7. Notwithstanding such uncertainties, and given the state-of-the-art for quantitative estimation of uncertainties in probabilistic risk analysis of this type, the staff regards the estimates of consequences and risks made in this Addendum reasonable.

6.1.6.6 Conclusion

In the preceding sections the staff has presented a probabilistic assessment of the consequences and risks via four aquatic pathways of exposure that could result from atmospheric fallout of radionuclides on the Great Lakes after atmospheric releases of radioactivity in severe accidents in the Fermi 2 reactor. Reasonably estimated values of nonmitigated risks to an individual and to society of delayed cancer fatalities from the four pathways of exposure were found to be lower than 5×10^{-8} and 6×10^{-2} per reactor-year of operation of the Fermi 2 facility. These values are of the same order of magnitude as the values presented in the FES. Furthermore, estimated risks of early death or injury to an individual or society from atmospheric fallout on the Great Lakes are very small without interdiction. However, in the event of a severe accident in the Fermi 2 reactor involving large atmospheric releases of radioactivity and with the possibility of wind blowing toward Lake Erie (the Great Lake nearest to Fermi 2) at the time of release, it is expected that emergency measures would be undertaken on behalf of the commercial fishermen and recreational population to avoid exposures from the radioactive plume. In addition, after fallout on Lake Erie, there might develop local areas in the nearshore waters of the lake where concentrations of radionuclides, as a result of nonuniform deposition and localized and temporary stagnation and stratification, might reach levels above protection action guide levels. It is expected that if monitoring detects such local "hot spots," mitigation measures such as temporary denial of the use of recreational facilities close to or drinking water drawn from these hot spots would be undertaken. Further, in the event of as large a fallout of radionuclides on Lake Erie as shown in Table 6.8, interdiction of the aquatic food pathway from the lake for about a year or so would substantially reduce the dose to an individual and the population (see Tables 6.11a and 6.12a). This would mean denial of about 40 million kilograms of edible fish from Lake Erie per year if a 1-year period of interdiction were undertaken. Longer periods of interdiction would substantially eliminate human exposures. With mitigation, doses to both an individual and the population would be less than reported for land pathways in the FES.

6.1.7 Environmental and Socioeconomic Consequences and Risks

In the FES the staff evaluated the release of radioactivity to groundwater in the event of an accident well beyond the design basis. The evaluation indicated the relative concentrations of important radionuclides that might be expected in Lake Erie. The results of the evaluation were reported in terms of a comparison of doses discussed in the LPGS (NUREG-0440). The potential environmental, societal, and economic consequences of such accidents are discussed in FES Section 6.1.4.4.

Section 6.1.6 of this Addendum has discussed the health impacts of fallout, but has not addressed all the environmental, societal, and economic risks of such accidents. These risks are further discussed in this Section. In the FES for the Floating Nuclear Power Plants (FNP FES) the staff concluded that the environmental risks (consequences and probabilities) from credible accidents involving both the airborne and liquid pathways are small, and that the socioeconomic impacts of floating nuclear power plants and land-based reactors were acceptable. Included were several different kinds of environmental and socioeconomic impacts of accidents. The primary difference between the Fermi 2 site on Lake Erie and coastal or estuary sites evaluated for severe accident socioeconomic and environmental impacts in the LPGS and the FNP FES is the drinking water pathway. That is, Lakes Erie and Ontario are used as a source of drinking water for relatively large populations, whereas at coastal and estuary sites there generally is no such pathway. In considering the Lake Erie and Lake Ontario drinking water pathways, however, Tables 6.12a through 6.12e indicate that the drinking water contribution to population doses from atmospheric fallout is a very small fraction of the estimated total population dose. Similarly, potential doses to a maximally exposed individual from drinking water are relatively small. Furthermore, the doses are interdictable.

Section 6.1.4.6 and Table 6.5 of the Fermi 2 FES identify average annual risks in several categories. Included are the costs of interdiction and mitigation. In computing the values stated, however, no costs, consequences, and risks were assessed for the areas occupied by the Great Lakes. The surface areas of the Great Lakes at distances 400 and 850 km (250 mi and 550 mi) from the Fermi 2 site are small percentages of the total land areas at the same distances.* As indicated, the principal health impacts from fallout on the Great Lakes are through fish ingestion and, to a much lesser extent, through drinking water.

*At 400 km the surface area of all of Lake Erie and portions of the other Great Lakes within such a radius is less than 25 percent of the total land area within a circle of the same radius. At 850 km all of the Great Lakes surface area is about 10 percent of the total area in a circle of similar radius.

However, the costs per unit area of mitigating the potential consequences of such radioactivity would not be expected to vary materially (by less than a factor of 2) from the costs expected for land areas. By neglecting the risks from fallout on water, therefore, the average annual risks identified in the FES could have been underestimated by less than a factor of 2. Finally, even if it is assumed that the risks identified in the FES were a factor of 2 greater, the staff's conclusions are not changed. These conclusions are that the risks from accidents at Fermi 2 are comparable to those for normal operation, and the risks of fatalities from accidents are small with respect to the risks of fatalities from other human activities in a comparatively sized population.

6.2.1 References for Section 6.1.6

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Simpson, H. J., C. R. Olsen, R. M. Trier, S. C. Williams; "Man Made Radionuclides and Sedimentation in the Hudson River Estuary;" Science; Vol. 194; Oct. 8, 1976; p. 179-182.

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---, NUREG-75/014, "Reactor Safety Study," WASH-1400, October 1975.

---, NUREG-0440, "Liquid Pathway Generic Study," February 1978.

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Table 6.6 Quantities of radionuclides in the atmospheric release from potential TC_{γ}' sequence

Radionuclide	Curies Released	Radionuclides	Curies Released
Co-58	4.34×10^{4}	Sb-127	4.14×10^{6}
Co-60	1.62×10^{4}	Sb-129	1.78×10^{7}
Kr-85	6.00×10^{5}	I-131	4.08×10^{7}
Kr-85m	2.03×10^{7}	I-132	6.66×10^{7}
Kr-87	2.22×10^{7}	I-133	7.80×10^{7}
Kr-88	5.03×10^{7}	I-134	2.81×10^{7}
Rb-86	1.86×10^{4}	I-135	6.20×10^{7}
Sr-89	7.35×10^{6}	Xe-133	1.81×10^{8}
Sr-90	2.90×10^{5}	Xe-135	3.97×10^{7}
Sr-91	7.73×10^{6}	Cs-134	5.39×10^{6}
Y-90	3.88×10^{4}	Cs-136	2.15×10^{6}
Y-91	1.07×10^{6}	Cs-137	3.38×10^{6}
Zr-95	1.36×10^{6}	Ba-140	1.25×10^{7}
Zr-97	1.26×10^{6}	La-140	1.71×10^{6}
Nr-95	1.33×10^{6}	Ce-141	1.33×10^{6}
Mo-99	8.78×10^{6}	Ce-143	1.12×10^{6}
Tc-99m	7.91×10^{6}	Ce-144	7.56×10^{5}
Ru-103	6.12×10^{6}	Pr-143	1.16×10^{6}
Ru-105	3.18×10^{6}	Nd-147	5.32×10^{6}
Ru-106	1.39×10^{6}	Np-239	1.43×10^{7}
Rh-105	2.76×10^{6}	Pu-238	5.07×10^{2}
Te-127	4.06×10^{6}	Pu-239	1.87×10^{2}
Te-127m	7.54×10^{5}	Pu-240	1.87×10^{2}
Te-129	2.04×10^{7}	Pu-241	3.02×10^{4}
Te-129m	3.63×10^{6}	Am-241	1.51×10
Te-131m	8.61×10^{6}	Cm-242	4.45×10^{3}
Te-132	8.12×10^{7}	Cm-244	2.05×10^{2}

Table 6.7 Radial and angular spans of the Great Lakes

		Radial span	
Lake	Angular span (sector)	Nearest shoreline to reactor, km (mi)	Farthest shoreline from reactor, km (mi)
Lake Erie	ENE, E, ESE	0	384 (240)
Lake Huron*	NNW, N, NNE, NE	56 (35)	320 (200)
Lake Michigan	W, WNW, NW	256 (160)	512 (320)
Lake Ontario	NE, ENE	320 (200)	640 (400)
Lake Superior	NW, NNW	512 (320)	832 (520)

*Includes Lake St. Clair and Georgian Bay.

Table 6.8 Wind direction probabilities and radionuclide deposition data for the Great Lakes

Radionuclide	Curies deposited by fallout				
	Lake Erie	Lake Huron	Lake Michigan	Lake Ontario	Lake Superior
Co-58	3.82×10^4	1.47×10^4	3.20×10^3	2.30×10^3	7.00×10^2
Co-60	1.43×10^4	5.53×10^3	1.30×10^3	8.00×10^2	2.00×10^2
Kr-85	0	0	0	0	0
Kr-85m	0	0	0	0	0
Kr-87	0	0	0	0	0
Kr-88	0	0	0	0	0
Rb-86	1.62×10^4	6.20×10^3	1.30×10^3	9.00×10^2	3.00×10^2
Sr-89	6.44×10^6	2.48×10^3	5.40×10^5	3.80×10^5	1.20×10^5
Sr-90	2.55×10^5	9.80×10^4	2.20×10^4	1.50×10^4	5.00×10^3
Sr-91	4.88×10^6	1.19×10^6	1.10×10^5	4.00×10^4	0
Y-90	4.80×10^4	2.45×10^4	7.70×10^3	6.50×10^3	2.30×10^3
Y-91	9.54×10^5	3.72×10^5	8.30×10^4	5.80×10^4	1.80×10^4
Zr-95	1.17×10^6	4.51×10^5	1.00×10^5	7.00×10^4	2.00×10^4
Zr-97	8.94×10^4	2.62×10^5	3.40×10^4	1.60×10^4	3.00×10^3
Nb-95	1.17×10^6	4.50×10^5	1.00×10^5	7.00×10^4	3.00×10^4
Mo-99	7.26×10^6	2.60×10^6	5.00×10^5	3.10×10^5	9.00×10^4
Tc-99m	7.06×10^6	2.69×10^6	5.50×10^5	3.40×10^5	9.00×10^4
Ru-103	5.37×10^6	2.07×10^6	4.60×10^5	3.10×10^5	9.00×10^4
Ru-105	1.57×10^6	2.40×10^5	1.00×10^4	0	0
Ru-106	1.23×10^6	4.77×10^5	1.10×10^5	7.00×10^4	2.00×10^4
Rh-105	2.30×10^6	8.20×10^5	1.40×10^5	8.00×10^4	2.00×10^4
Te-127	3.53×10^6	1.34×10^6	2.80×10^5	1.80×10^5	5.00×10^4
Te-127m	6.63×10^5	2.56×10^5	5.60×10^4	3.90×10^4	1.20×10^4
Te-129	1.09×10^7	1.78×10^6	1.00×10^5	0	0
Te-129m	3.18×10^6	1.22×10^6	2.60×10^5	1.90×10^5	6.00×10^4
Te-131m	6.66×10^5	2.19×10^6	3.50×10^5	1.90×10^5	5.00×10^4
Te-132	6.78×10^7	2.46×10^7	4.90×10^6	3.00×10^6	8.00×10^5
Sb-127	3.48×10^6	1.27×10^6	2.50×10^6	1.70×10^5	5.00×10^4
Sb-129	8.68×10^6	1.30×10^6	4.00×10^4	1.00×10^4	0
I-131	3.53×10^7	1.34×10^7	2.80×10^6	1.90×10^6	5.00×10^5
I-132	6.34×10^7	2.48×10^7	4.90×10^6	3.10×10^6	9.00×10^5
I-133	5.57×10^7	1.77×10^7	2.50×10^6	1.30×10^6	3.00×10^5
I-134	5.90×10^6	8.00×10^4	0	0	0
I-135	3.53×10^7	7.20×10^6	4.00×10^5	1.00×10^5	0
Xe-133	0	0	0	0	0
Xe-135	0	0	0	0	0
Cs-134	4.47×10^6	1.83×10^6	4.10×10^5	2.90×10^5	9.00×10^4
Cs-136	1.87×10^6	7.10×10^5	1.60×10^5	1.10×10^5	3.00×10^4
Cs-137	2.97×10^6	1.15×10^6	2.50×10^5	1.70×10^5	5.00×10^4

Table 6.8 (continued)

Radionuclide	Curies deposited by fallout Lake Erie	Lake Huron	Lake Michigan	Lake Ontario	Lake Superior
Ba-140	1.08×10^7	4.10×10^6	9.00×10^5	6.00×10^5	2.00×10^5
La-140	2.38×10^6	1.29×10^6	4.10×10^5	3.40×10^5	1.20×10^5
Ce-141	1.17×10^6	4.52×10^5	1.00×10^5	7.00×10^4	2.00×10^4
Ce-143	8.76×10^5	2.92×10^5	4.90×10^4	2.70×10^4	7.00×10^3
Ce-144	6.65×10^5	2.57×10^5	5.60×10^4	3.90×10^4	1.20×10^4
Pr-143	1.01×10^6	3.88×10^5	8.30×10^4	5.80×10^4	2.00×10^4
Nd-147	4.60×10^5	1.74×10^5	3.70×10^4	2.50×10^4	8.00×10^3
Np-239	1.17×10^7	4.12×10^6	7.00×10^5	5.00×10^5	2.00×10^5
Pu-238	4.47×10^2	1.73×10^2	3.80×10	2.70×10	8.00
Pu-239	1.64×10^2	6.30×10	1.40×10	1.00×10	4.00
Pu-240	1.64×10^2	6.30×10	1.40×10	1.00×10	3.00
Pu-241	2.67×10^4	1.03×10^4	2.30×10^3	1.60×10^3	5.00×10^2
Am-241	1.34×10	5.20	1.20	8.00×10	2.00×10
Cm-242	3.92×10^3	1.51×10^3	3.40×10^2	2.30×10^2	7.00×10
Cm-244	1.80×10^2	6.90×10	1.50×10	1.00×10	3.00×10
Annual average wind direction probability toward the lake	0.243	0.309	0.157	0.186	0.121

*Magnitude averaged over 91 sampling times.

Table 6.9 Grate Lakes parameters*

Lake name	Surface area (m^2)	Volume (m^3)	Mean water depth d_1 (m)	Mean sediment depth d_2 (m)	Kf) (cm/yr)	K_d	v (cm/yr)	Outflow rate (m^3/yr)
Erie	2.567×10^{10}	0.458×10^{12}	18	10	0.4	27,000 Cs 2,400 Sr	0.05	1.752×10^{11}
Huron	5.951×10^{10}	4.6×10^{12}	77	10	0.4	27,000 Cs 2,400 Sr	0.05	1.573×10^{11}
Michigan	5.802×10^{10}	4.871×10^{12}	84	10	0.4	27,000 Cs 2,400 Sr	0.05	1.582×10^{11}
Ontario	1.968×10^{10}	1.636×10^{12}	83	10	0.4	27,000 Cs 2,400 Sr	0.05	2.091×10^{11}
Superior	8.237×10^{10}	12.221×10^{12}	148	10	0.4	27,000 Cs 2,400 Sr	0.05	0.662×10^{11}

*Values of these parameters were selected from NUREG-0440.

Table 6.10 Great Lakes population annual usage parameters*

Lake name	Fish catch, edible weight (kg)	Drinking water (persons)	Shoreline (person hours)	Swimming (person hours)
Erie	3.44×10^7	10.6×10^6	3.5×10^8	1.8×10^8
Huron	0.57×10^7	1.8×10^6	4.4×10^7	2.1×10^7
Michigan	1.65×10^7	5.1×10^6	3.5×10^8	1.8×10^8
Ontario	0.32×10^7	1.0×10^6	1.6×10^8	7.8×10^7
Superior	1.06×10^7	3.3×10^6	1.9×10^7	9.3×10^6

*Values of these parameters were selected from NUREG-0440.

Table 6.11a Whole-body dose to an individual from Lake Erie for different durations of use after contamination*

Period of Use	Whole-body dose (rems)					
	Drinking water	Aquatic food** Recreational	Aquatic food** Commercial	Shoreline	Swimming	Total**
1 day	4×10^{-3}	2×10^{-3}	2×10^{-3}	3×10^{-6}	2×10^{-5}	6×10^{-3}
30 days	1×10^{-1}	2	2	6×10^{-4}	2×10^{-4}	2
1 year	6×10^{-1}	40	40	3 c 10^{-2}	6×10^{-4}	40
3 years	8×10^{-1}	60	60	1×10^{-1}	8×10^{-4}	60
10 years	8×10^{-1}	60	60	2×10^{-1}	8×10^{-4}	60
85 years	8×10^{-1}	60	60	5×10^{-1}	8×10^{-4}	60

*Probability of contamination of Lake Erie is 6×10^{-6} per reactor year, calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**Dose from either recreational catch or commercial catch, whichever is higher, is included in the total dose.

Table 6.11b Whole-body dose to an individual from Lake Huron for different durations of use after contamination*

Period of Use	Whole-body dose (rems) Drinking water	Aquatic food** Recreational	Aquatic food** Commercial	Shoreline	Swimming	Total**
1 day	2×10^{-4}	8×10^{-5}	8×10^{-5}	1×10^{-7}	7×10^{-7}	3×10^{-4}
30 days	4×10^{-3}	6×10^{-2}	6×10^{-2}	2×10^{-5}	7×10^{-6}	6×10^{-2}
1 year	4×10^{-2}	2	2	1×10^{-3}	3×10^{-5}	2
3 years	8×10^{-2}	5	5	7×10^{-3}	6×10^{-5}	5
10 years	1×10^{-1}	9	8	3×10^{-2}	8×10^{-5}	9
85 years	2×10^{-1}	10	10	8×10^{-2}	8×10^{-5}	10

*Probability of contamination of Lake Huron is 7.5×10^{-6} per reactor year, calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**Dose from either recreational catch or commercial catch, whichever is higher, is included in the total dose.

Table 6.11c Whole-body dose to an individual from Lake Michigan for different durations of use after contamination*

Period of Use	Whole-body dose (rems) Drinking water	Aquatic food** Recreational	Aquatic food** Commercial	Shoreline	Swimming	Total**
1 day	3×10^{-5}	2×10^{-5}	2×10^{-5}	2×10^{-8}	2×10^{-7}	5×10^{-5}
30 days	9×10^{-4}	1×10^{-2}	1×10^{-2}	5×10^{-6}	2×10^{-6}	1×10^{-2}
1 year	9×10^{-3}	5×10^{-1}	5×10^{-1}	3×10^{-4}	7×10^{-6}	5×10^{-1}
3 years	2×10^{-2}	1	1	1×10^{-3}	1×10^{-5}	1
10 years	3×10^{-2}	2	2	5×10^{-3}	2×10^{-5}	2
85 years	4×10^{-1}	3	3	2×10^{-2}	2×10^{-5}	3

*Probability of contamination of Lake Michigan is 4×10^{-6} per reactor year, calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**Dose from either recreational catch or commercial catch, whichever is higher, is included in the total dose.

Table 6.11d Whole-body dose to an individual from Lake Ontario for different durations of use after contamination*

Period of Use	Whole-body dose (rems)					
	Drinking water	Aquatic food** Recreational	Aquatic food** Commercial	Shoreline	Swimming	Total**
1 day	7×10^{-5}	4×10^{-5}	3×10^{-5}	4×10^{-8}	2×10^{-7}	1×10^{-4}
30 days	2×10^{-3}	3×10^{-2}	3×10^{-2}	9×10^{-6}	3×10^{-6}	3×10^{-2}
1 year	2×10^{-2}	9×10^{-1}	8×10^{-1}	6×10^{-4}	1×10^{-5}	9×10^{-1}
3 years	5×10^{-2}	2	2	3×10^{-3}	3×10^{-5}	2
10 years	5×10^{-2}	3	3	1×10^{-2}	3×10^{-5}	3
85 years	5×10^{-2}	3	3	3×10^{-2}	3×10^{-5}	3

*Probability of contamination of Lake Ontario is 4.5×10^{-6} per reactor year, calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**Dose from either recreational catch or commercial catch, whichever is higher, is included in the total dose.

Table 6.11e Whole-body dose to an individual from Lake Superior for different durations of use after contamination*

Period of Use	Whole-body dose (rems)					
	Drinking water	Aquatic food** Recreational	Aquatic food** Commercial	Shoreline	Swimming	Total**
1 day	3×10^{-6}	2×10^{-6}	1×10^{-6}	1×10^{-9}	9×10^{-9}	5×10^{-6}
30 days	8×10^{-5}	1×10^{-3}	1×10^{-3}	4×10^{-7}	1×10^{-7}	1×10^{-3}
1 year	8×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-5}	6×10^{-7}	4×10^{-2}
3 years	2×10^{-3}	1×10^{-1}	1×10^{-1}	1×10^{-4}	1×10^{-6}	1×10^{-1}
10 years	3×10^{-3}	2×10^{-1}	2×10^{-1}	6×10^{-4}	2×10^{-6}	2×10^{-1}
85 years	6×10^{-3}	4×10^{-1}	4×10^{-1}	2×10^{-3}	2×10^{-6}	4×10^{-1}

*Probability of contamination of Lake Superior is 3×10^{-6} per reactor year. Calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**Dose from either recreational catch or commercial catch, whichever is higher, is included in the total dose.

Table 6.12a Whole-body population dose from Lake Erie for durations of use after contamination*

Period of Use	Population dose (person rems)				
	Drinking water	Aquatic food**	Shoreline	Swimming	Total
1 day	2×10^4	3×10^3	2×10	1×10^2	2×10^4
30 days	5×10^5	2×10^6	3×10^3	1×10^3	3×10^6
1 year	3×10^6	5×10^7	1×10^5	5×10^3	5×10^7
3 years	4×10^6	8×10^7	5×10^5	6×10^3	8×10^7
10 years	4×10^6	8×10^7	1×10^6	6×10^3	9×10^6
85 years	4×10^6	8×10^7	2×10^6	6×10^3	9×10^7

*Probability of contamination of Lake Erie is 6×10^{-6} per reactor year, calculated as the product of probabilities of the atmosphere release and the wind directions toward the lake.

**From commercial catch only.

Table 6.12b Whole-body population dose from Lake Huron for durations of use after contamination*

Period of Use	Population dose (person rems)				
	Drinking water	Aquatic food**	Shoreline	Swimming	Total
1 day	1×10^2	2×10	7×10^{-2}	6×10^{-1}	1×10^2
30 days	4×10^3	2×10^4	1×10	6	2×10^4
1 year	4×10^4	5×10^5	9×10^2	3×10^1	5×10^5
3 years	8×10^4	1×10^6	4×10^3	5×10^1	1×10^6
10 years	1×10^5	2×10^6	2×10^4	7×10^1	2×10^6
85 years	2×10^5	2×10^6	5×10^4	7×10^1	2×10^6

*Probability of contamination of Lake Huron is 7.5×10^{-6} per reactor year. Calculated as the product of probabilities of the atmosphere release and the wind directions toward the lake.

**From commercial catch only.

Table 6.12c Whole-body population dose from Lake Michigan for durations of use after contamination*

Period of Use	Population dose (person rems)				
	Drinking water	Aquatic food**	Shoreline	Swimming	Total
1 day	8 x 10	1 x 10	1×10^{-1}	1	1×10^{2}
30 days	2×10^{3}	9×10^{3}	3 x 10	1 x 10	1×10^{4}
1 year	2×10^{4}	3×10^{5}	1×10^{3}	5 x 10	3×10^{5}
3 years	5×10^{4}	7×10^{5}	7×10^{3}	9 x 10	8×10^{5}
10 years	8×10^{4}	1×10^{6}	3×10^{4}	1×10^{2}	1×10^{6}
85 years	1×10^{5}	2×10^{6}	9×10^{4}	1×10^{2}	2×10^{6}

*Probability of contamination of Lake Michigan is 4×10^{-6} per reactor year. Calculated as the product of probabilities of the atmosphere release and the wind directions toward the lake.

**From commercial catch only.

Table 6.12d Whole-body population dose from Lake Ontario for durations of use after contamination*

Period of Use	Population dose (person rems)				
	Drinking water	Aquatic food**	Shoreline	Swimming	Total
1 day	3 x 10	5	9×10^{-2}	7×10^{-1}	40
30 days	9829	4×10^{3}	2×10^{1}	9	5×10^{3}
1 year	9×10^{3}	1×10^{5}	1×10^{3}	5×10^{1}	1×10^{5}
3 years	2×10^{4}	3×10^{5}	7×10^{3}	8×10^{1}	3×10^{5}
10 years	2×10^{4}	4×10^{5}	2×10^{4}	1×10^{2}	4×10^{5}
85 years	3×10^{4}	4×10^{5}	6×10^{4}	1×10^{2}	5×10^{5}

*Probability of contamination of Lake Ontario is 4.5×10^{-6} per reactor year. Calculated as the product of probabilities of the atmosphere release and the wind directions toward the lake.

**From commercial catch only.

Table 6.12e Whole-body population dose from Lake Superior for different durations of use after contamination*

Period of Use	Population dose (person rems)				
	Drinking water	Aquatic food**	Shoreline	Swimming	Total
1 day	5	6×10^{-1}	4×10^{-4}	3×10^{-3}	6
30 days	1×10^{2}	5×10^{2}	1×10^{-1}	4×10^{-2}	6×10^{2}
1 year	1×10^{3}	2×10^{4}	7	2×10^{-1}	2×10^{4}
33 years	3×10^{3}	4×10^{4}	4×10	4×10^{-1}	5×10^{4}
10 years	6×10^{3}	1×10^{5}	2×10^{2}	7×10^{-1}	1×10^{5}
85 years	9×10^{3}	2×10^{5}	7×10^{2}	8×10^{-1}	2×10^{5}

*Probability of contamination of Lake Superior is 3×10^{-6} per reactor year, calculated as the product of probabilities of the atmospheric release and the wind directions toward the lake.

**From commercial catch only.

10 DISCUSSION OF COMMENTS RECEIVED ON THE DRAFT ENVIRONMENTAL STATEMENT

10.6 Environmental Impacts of Postulated Accidents (DOI, A-74)

The Department of the Interior commented on and expressed concern regarding several issues. The Department noted that its concerns over impacts of transmission line rights-of-way and control of chlorine residue had been addressed and that proposed preoperational and operational aquatic environmental monitoring programs appear to be adequate.

Concerns regarding the atmospheric deposition of radionuclides on the Great Lakes are addressed in Sections 6.1.6 and 6.1.7 of this Addendum.

Effects on the lakes as a result of releases of radioactivity to groundwater are an area of DOI concern. Subsequent paragraphs of this section discuss groundwater retardation and flow conditions, groundwater flow reversals and groundwater monitoring, and leaching of core debris into groundwater. In response to the DOI request regarding the calculations, estimates, and assumptions used to determine entry of radionuclides into the lakes, the sources for these are given.

The groundwater flow and retardation factors used in the analysis of severe accidents are based on the assumptions and references reported in the LPGS (NUREG-0440),* and onsite data reported by the applicant. Specific flow-related parameters selected for the groundwater analysis of severe accidents reported in FES Section 6.1.4.5 that are conservative were purposely chosen because of the relatively uncertain characteristics of the fractured dolomite that underlies the reactor. The retardation factors for the dolomite were based on the work of Isherwood in NUREG/CR-0912 (1981).

Groundwater movement at the site is generally toward Lake Erie. The need for monitoring radiological constituents in groundwater was considered by the staff during preparation of the FES. No need for such monitoring was identified because of the direction of flow and the low likelihood of any water users intercepting flow passing under the plant. Although the groundwater gradient varies as a result of a number of factors, it is generally mild and can be reversed by the extensive development of offsite groundwater supplies by offsite users. Whether such development occurs is speculative, but because of the relatively poor water quality, it is doubtful. However, by letter dated February 25, 1982, the applicant has committed to include consideration of groundwater reversals in his operational radiological monitoring program and to institute data collection if such reversals appear likely.

Accident consequences resulting from groundwater leaching of core debris were considered in both the LPGS (NUREG-0440) and in the Fermi 2 FES. It was concluded in both cases that the magnitude and timing of such releases would

*References cited in this section of the Addendum are listed at the end of this Chapter in Section 10.9.1.

result in a relatively small contribution to estimated doses compared to the prompt source and, therefore, could be neglected. Furthermore, it was concluded that onsite interdiction could be expected to eliminate the offsite dose potential of both the prompt and leach release source terms.

Part of the radioactivity deposited on the ground surface can be expected to runoff with rainfall and to percolate into the ground and reach aquifers. Both potential sources of radioactivity following normal releases and accidents were considered by the staff in a qualitative manner. Based upon the observations of Simpson et al. and Ng et al., the consequences of atmospheric fallout from testing of weapons on surface water concentrations of important radionuclides may be used to indicate the relative magnitude of concentration in water caused by atmospheric fallout following a severe reactor accident. The findings of both groups of authors indicate low percentages of important long-lived radionuclides in surface water after fallout. Therefore, the staff concludes that the long-term concentration levels to be expected in surface water and the related dose potential after a severe reactor accident would be a very small fraction of that which could occur from direct fallout immediately following the accident.

10.9.1 Additional References for Section 10.6

Ng, Y. C., W. L. Robertson, and D. W. Wilson; "Modelling Radiation Exposures to Population from Radioactivity Released to the Environment" in Environmental Behavior of Radionuclides Released in the Nuclear Industry; International Atomic Energy Agency, Vienna, 1973.

Simpson, H. J., C. R. Olsen, R. M. Trier, S. C. Williams; "Man Made Radionuclides and Sedimentation in the Hudson River Estuary;" Science; Vol. 194; Oct. 8, 1976; p. 179-182.

U.S. Nuclear Regulatory Commission, Final Environmental Statement, "Floating Nuclear Power Plants," Docket No. STN 50-437.

---, NUREG-0440, "Liquid Pathway Generic Study," February 1978.

---, NUREG/CR-0912, D. Isherwood, "Geoscience Data Base Handbook for Modeling a Nuclear Waste Repository," Lawrence Livermore Laboratory, January 1981.

APPENDIX A

Comments on the Draft Environmental Statement

ER 81/965

JUN 18 1981

RECEIVED
JUN 22 1981
U.S. NUCLEAR REGULATORY COMMISSION

Mr. B. J. Youngblood, Chief
Licensing Branch No. 1
Division of Licensing
Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Youngblood:

Thank you for your letter of May 8, 1981, transmitting copies of the draft environmental impact statement, operating license stage, for the Enrico Fermi Atomic Power Plant, Unit 2, Monroe County, Michigan.

Our comments are presented according to the format of the statement or by subject.

Ecology

Concerns regarding impacts to fish and wildlife resources resulting from plant operation have been expressed previously in our comments on the final environmental statement for the construction permit and subsequent environment report supplements during the Operating License Stage.

Our stated concerns over impacts of transmission line right-of-ways and control of chlorine residuals have been addressed. The proposed preoperational and operational aquatic environmental monitoring should be adequate to determine if further mitigation will be required, especially in regard to intake impingement and entrainment of fish.

Releases to Groundwater

An assessment of the consequences of seven hypothetical accidents on Lake Erie and Lake Ontario is only found under the section "Releases to Ground Water" on page 6-25. Apparently the atmospheric deposition of radionuclides in the lakes was not included in the assessment of atmospheric releases on pages 6-13 to 6-25. Since some of the accident sequences involve the release of substantial quantities of long-lived radionuclides, the importance of assessing not only the health effects but also the environmental, social, and economic consequences of the entry of radionuclides into the lakes should be obvious. The atmospheric deposition of radionuclides should receive further study at Great Lake sites where a substantial fraction of radionuclides released could be deposited in the lakes.

The effects on the lakes due to releases to ground water are primarily determined by both the estimate of the rate of movement of the released radionuclides through the 460-foot distance between the reactor and Lake Erie, and by the size of the source terms for the long-lived radionuclides. The rate of movement is dependent on estimates of ground water velocity and so-called retardation factors. Although numerical values for these are given on pages 6-27 and 6-28, the parameters used and assumptions made to arrive at these estimates are not described. Therefore, it is not possible to evaluate whether the estimates are adequately conservative.

The source term for the radionuclides in the ground is apparently that used in the Liquid Pathway Generic Study (NUREG-0440). There it was limited to the prompt release of 15 percent of the sump water; it did not include leaching from the core debris. The uncertainties concerning leaching rates were raised in the generic study, but there is no indication in the present environmental statement that leaching of the core debris was assessed at this site. It is also not clear whether the assumed prompt release of 15 percent of the sump water is an adequate representation of the total release from this source that could occur in the aftermath of an accident.

It is indicated that the consequences in Lake Erie and Lake Ontario due to the releases to ground water would be largely economic or social. It is not clear that these effects have been evaluated and, if so, whether they are included in the estimates of costs shown in tables 6.4 and 6.5 and in figure 6.6.

One of the findings of NRC's Independent Risk Assessment Review Group was that it is very difficult to follow detailed calculations through NRC's Reactor Safety Study. The assessment of severe accident consequences relating to Lakes Erie and Ontario is based in part on that Reactor Safety Study, in part on the Liquid Pathway Generic Study, and in part on subsequent reports. We believe difficulties have been compounded. We recommend that calculations, estimates, and assumptions used to determine the entry into the lakes be made available for review.

Monitoring of ground water during operation should be specifically addressed. Water quality monitoring during operation is discussed on page 5-7 but it is not clear whether this will include monitoring both quality of ground water and water levels. The hydraulic gradients of the principal aquifer are fairly low; thus the gradients could easily become changed and redirected by area development during the life of the plant. We suggest that periodic monitoring of ground water levels and radioactivity should be continued at appropriate intervals in wells properly located to detect any major change in gradients.

We hope these comments will be helpful to you in the preparation of a final statement.

Sincerely,

CECIL S. HOFFMANN
Special Assistant to
Assistant SECRETARY

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16. ABSTRACT *(200 words or less)*

The Final Environmental Statement for the Enrico Fermi Atomic Power Plant related to operation was issued during August 1981. The Final Environmental Statement was the second assessment of the environmental impact associated with the construction and operation of the Fermi 2 Nuclear Power Plant, located on Lake Erie in Monroe County, Michigan. The Draft Environmental Statement was issued in April 1981. The first assessment was the Final Environmental Statement related to construction issued in July 1972 prior to issuance of the Fermi 2 construction permit.

This Addendum includes the NRC staff response to comments by the Department of the Interior that were not included in the Final Environmental Statement, dated August 1981.

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